Containership Residual Fuel Homogenization and Emulsification Technology Overview

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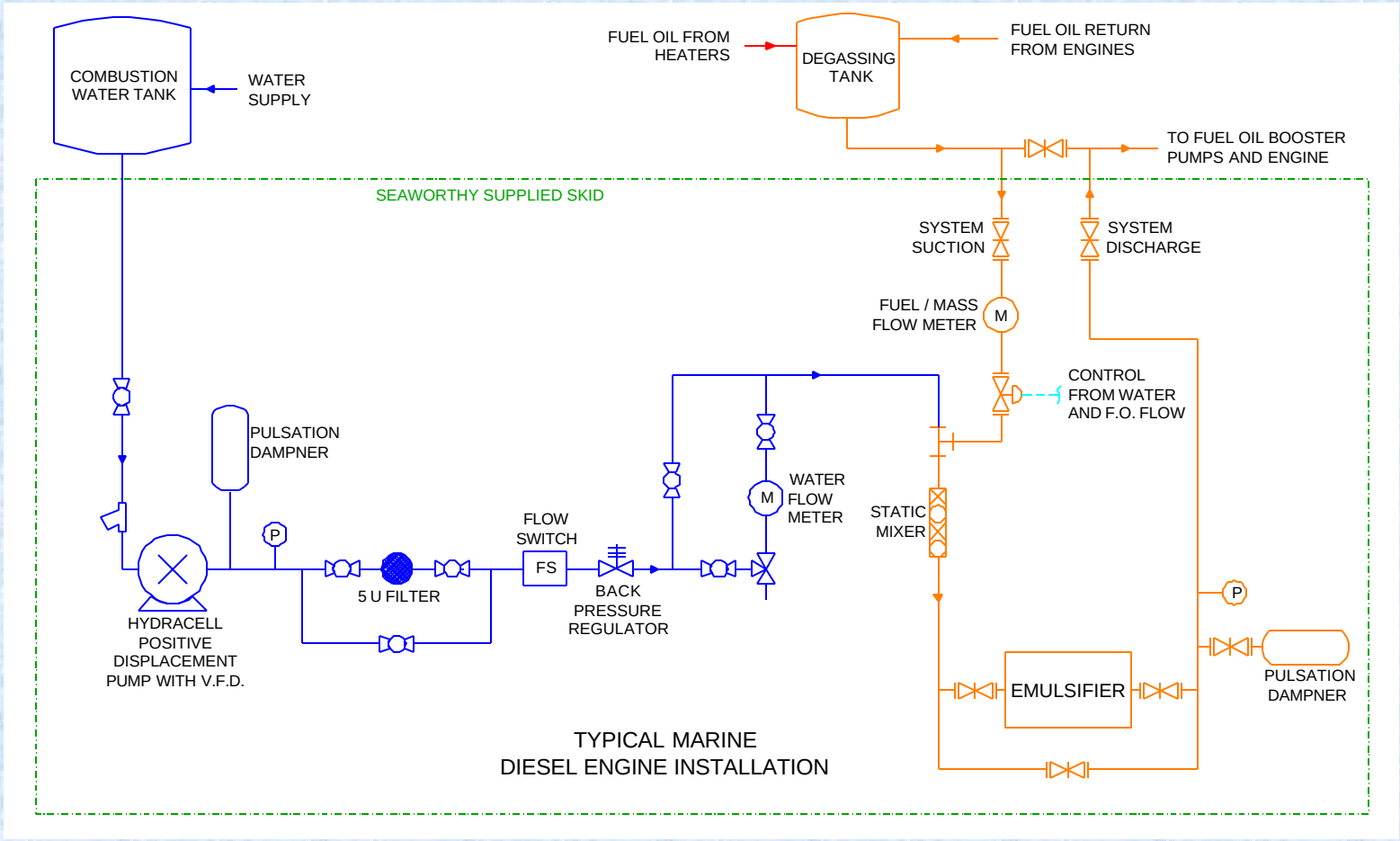
High Energy Water-in-Fuel Homogenization Emulsification (H/E) System



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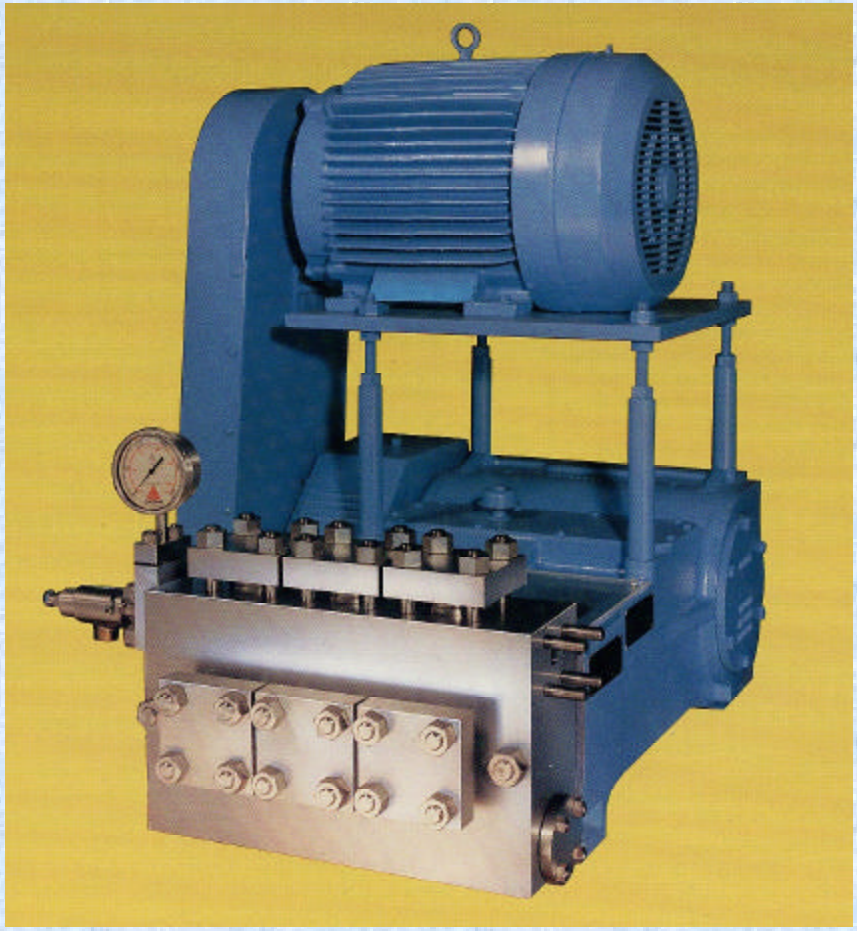
Typical Water-in-Fuel (H/E) System



System Components

- Oil pump and integral homogenizer valve
- Static mixer
- Positive displacement water pump with VFD flow control
- PLC-based controls

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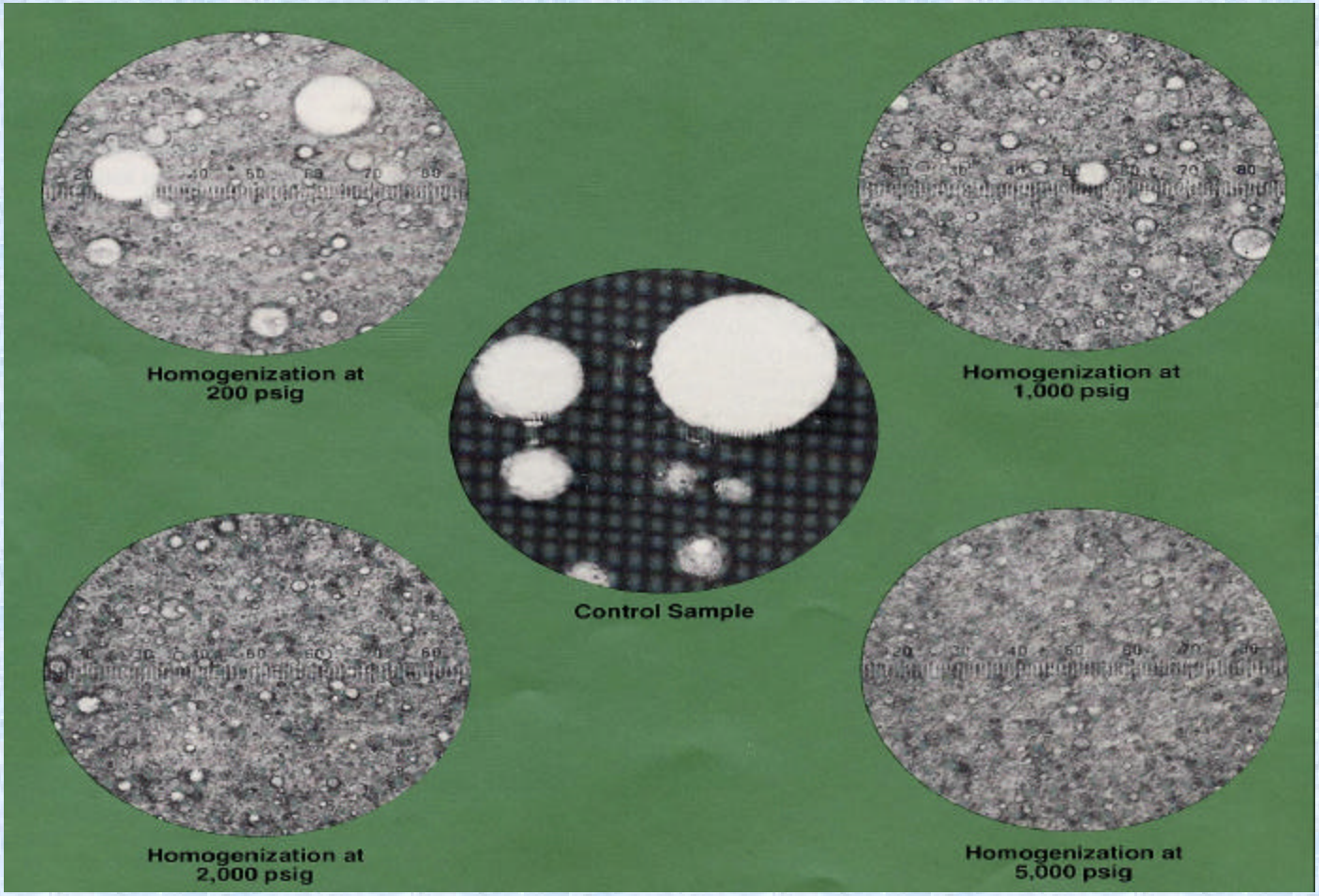
Photomicrograph Comparisons of High-Energy Homogenization of Water-in-Fuel



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Projected Effects of H/E System

Nitrogen Oxides (NOx)

- Peak temperature dependent, formed during combustion process
- Actual in service values can be 7-10% greater than test bed emissions
- Controlled emission levels vary directly with water flow
- 1% water-in-fuel yields approximately 1% reduction in NOx
- H/E demonstration project target goal = 25% reduction in NOx

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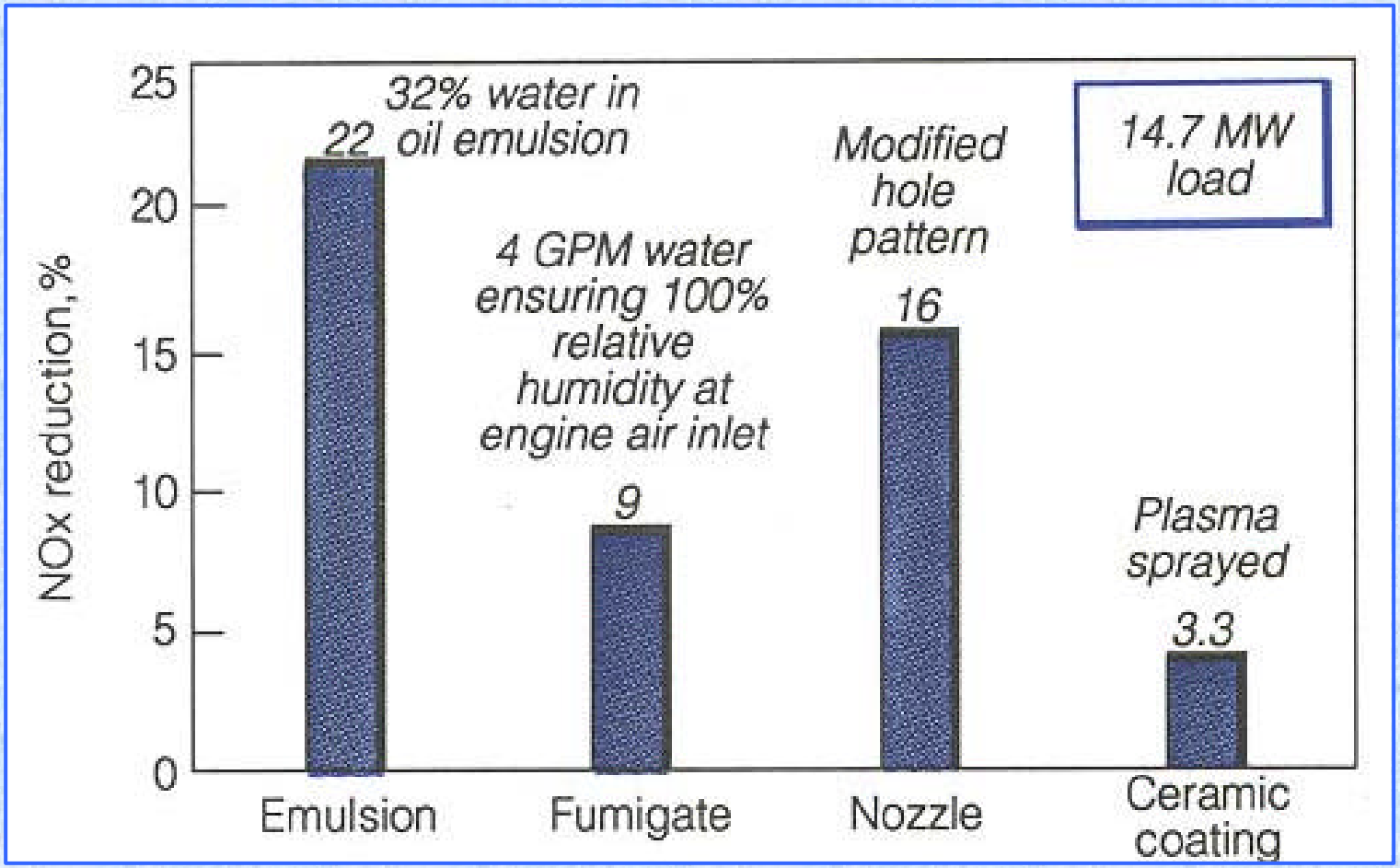
Seaworthy's NO_x Reduction Data From Residual Oil Slow Speed Diesel Applications



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Projected Effects of H/E System

Particulate Matter (PM)

- Clumps of small particles of partially burned fuel and lube oil
- H/E reduces PM at low water-in-fuel ratios
- Increase in PM at higher ratios, but still invisible stack (opacity<5)

Methane and Non Methane Hydrocarbons (HC)

- H/E reduces unburned hydrocarbons and odor

Carbon Dioxide (CO_2)

- Emission level varies directly with quantity of fuel burned
- 1% reduction in fuel yields approximately 1% reduction in CO_2

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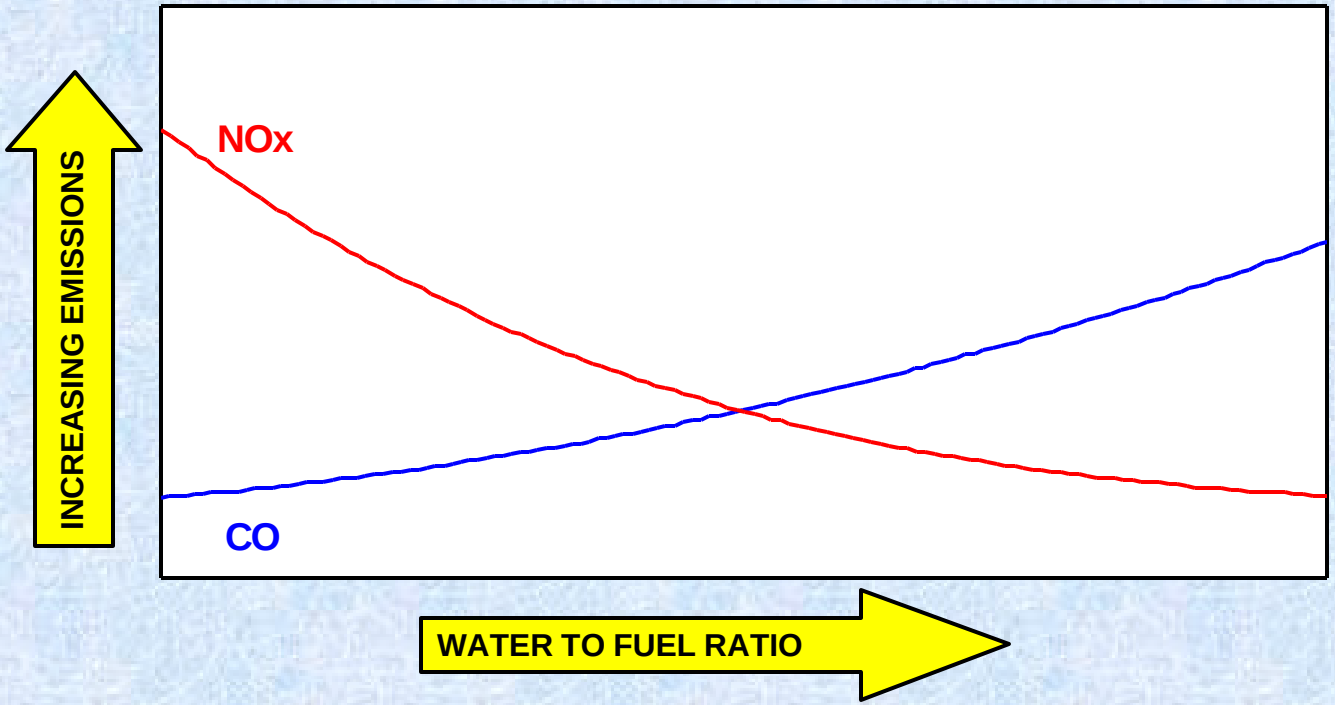
Projected Effects of H/E System

Carbon Monoxide (CO)

- Emission level varies directly with water-in-fuel ratio
- Balance between optimum water flow and emission levels to be determined during H/E demonstration project



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Shipboard Design Considerations for Marine Residual Fuel H/E Applications

- Reserve capacity in the fuel oil injection pumps
- Procedures/modifications on the fuel oil system for starting or stopping on residual fuels and change-over to emulsified fuels
- Modifications to the Engine Control System
- Special adjustments to permit maneuvering
- Changes or adjustments to the bridge/engine telegraph
- Operation on residual fuels in open water and emulsified fuel in coastal areas (or operation on economy emulsions in open water)
- Operation on low sulfur fuels
- Suitability of H/E technology to both main and auxiliary diesel engines, ability to interface with several different OEMs

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Statewide Emissions for a Typical West Coast - Hawaii Containership

Transiting main engine: 25 trips x 600 miles/trip x nm/1.15 mi. x hr/23 nm x 20,100 Kw x 17 g NOx/Kw-hr x lb/454 g x Ton/2000 lbs = **213 Tons NOx/yr**.

Transiting auxiliary engines: 25 trips x 600 miles/trip x nm/1.15 mi. x hr/23 nm x 2,000 Kw x 13 g NOx/Kw-hr x lb/454 g x Ton/2000 lbs = **16.2 Tons NOx/yr**.

Maneuvering main engine: 25 trips x 2 calls/trip x 1.9 hrs/call x 1,257 Kw x 19 g NOx/Kw-hr x lb/454 g x Ton/2000 lbs = **2.5 Tons NOx/yr**.

Maneuvering auxiliary engines: 25 trips x 2 calls/trip x 1.9 hrs/call x 2,400 Kw x 13 g NOx/Kw-hr x lb/454 g x Ton/2000 lbs = **3.2 Tons NOx/yr**.

Hotelling: 25 trips x 2 calls/trip x 51.1 hrs/call x 1100 Kw x 13 g NOx/Kw-hr x lb/454 g x Ton/2000 lbs = **40.2 Tons NOx/yr**.

Total Emissions: **275 Tons** NOx/yr.

H/E Target Goal = 25% reduction or approximately 70 Tons NOx

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California Air Districts Affected by Typical Containership Coastal Transit

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Estimated NO_x Emissions Reductions by District

District	Shipping Lane Miles per Trip	Emissions Reductions per Trip (tons)	Emissions Reductions per Year (tons)	Emissions Reductions, 5 Years (tons)
SCAQMD (Includes Long Beach, LA)	62	0.48	12	60
Ventura	74	0.28	7	35
Santa Barbara	165	0.64	16	80
San Luis Obispo	69	0.28	7	35
Monterey Bay Unified	95	0.36	9	45
BAAQMD (Includes San Francisco)	135	0.76	19	96
Total	**600**	**2.8**	**70**	**350**

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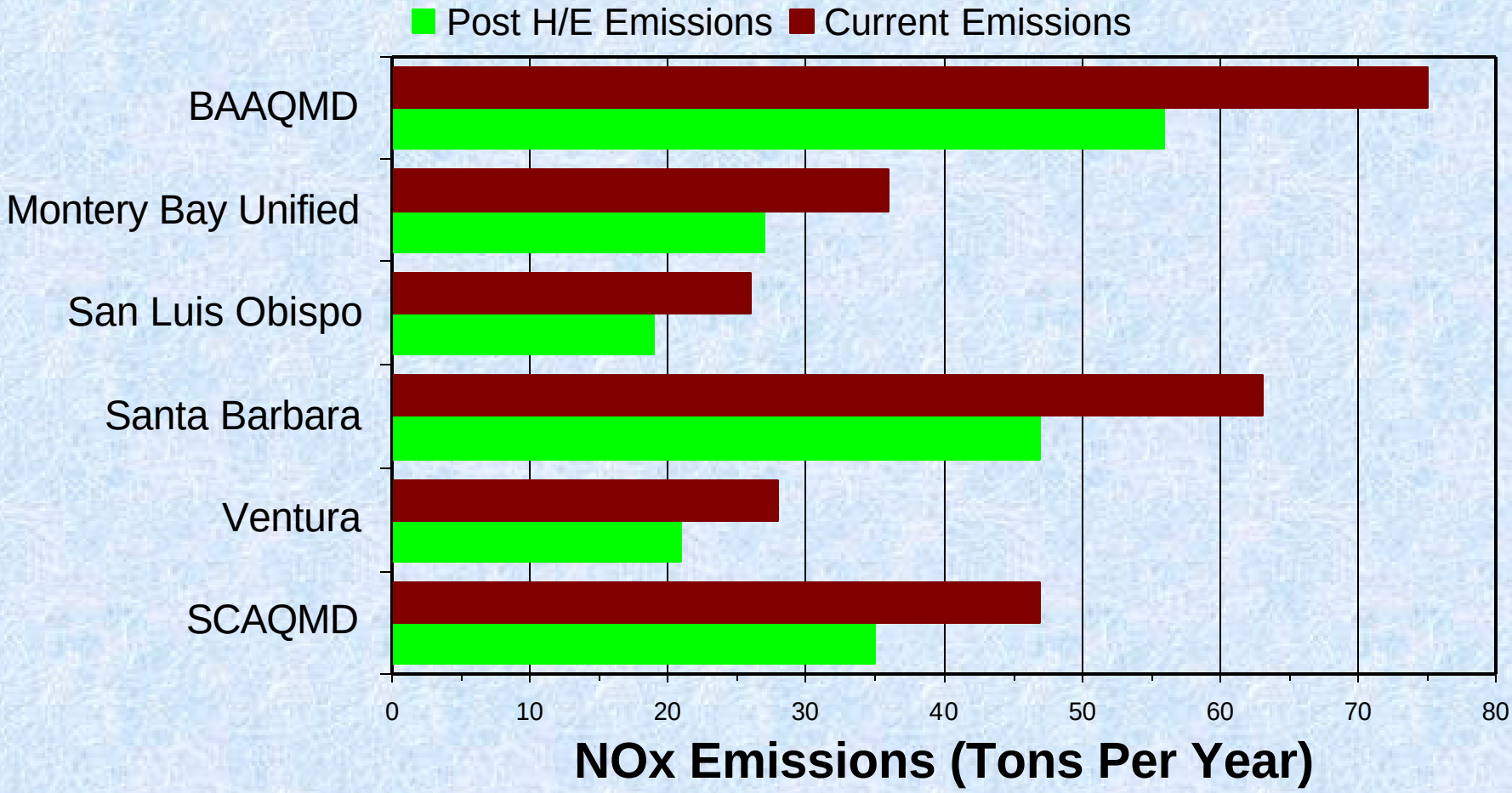
Predicted Annual Emissions Reductions with Shipboard Emulsification and Homogenization



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Projected Fuel and CO_2 Reductions

- There are no fuel or CO2 reductions with high water percentages
- Fuel and CO2 reductions of up to 3% are possible with economy emulsions

Containership Design Performance Fuel Consumption	per Voyage
• 90% MCR (1.25 BBL/MI) Eastbound/Westbound	5400 BBL
• 80% MCR (1.00 BBL/MI) Coastwise	600 BBL
• 3% fuel savings (excluding coastwise, man., dockside)	162 BBL

Assuming a fuel cost of $165 / MT this amounts to potential fuel savings of over $100,000 per year

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Shipboard H/E System Demonstration Project
Estimated Cost Summary

- Application engineering / preliminary design $40,000
- H/E system design and fabrication $295,000
  - Detail design
  - Regulatory approvals
  - Component purchasing
  - Assembly/fabrication
  - Design, operating and M&R documentation development
  - Factory acceptance testing/shipping
  - Start-up, commissioning and system tuning
  - Training
  - Reporting

(cont'd)

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Shipboard Demonstration Project
Estimated Cost Summary, cont'd

- H/E system installation $30,000
- Emission testing $35,000
  - Pre H/E system installation
  - Post H/E system installation
  - Reporting

Total estimated cost for H/E system $400,000

Note: Cost does not include contribution of operator in-kind services such as project management, port engineer supervision, shipboard labor (training, operation, maintenance), fuel for testing, consumable materials, and other direct costs (communications, drawings, reproduction, etc.)

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Estimated Cost per Ton of NO_x Reduced

- Statewide annual emission reduction:
  - Approx. 70 tons per year
- Statewide cost-effectiveness:
  - Using 5 years, 3% interest rate
  - CRC = $i(1+i)^n/(1+i)^n - 1 = 0.218$
  - Cost ~ $400,000(0.218) = $87,200
- CE = $87,200 / 70 Ton (one year) = $1246/Ton NO_x ~ $0.62/ lb NO_x
- CE = $87,200 / 350 Ton (five years) = $253/Ton NO_x ~ $0.13 / lb NO_x

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Thank You for Your Kind Attention